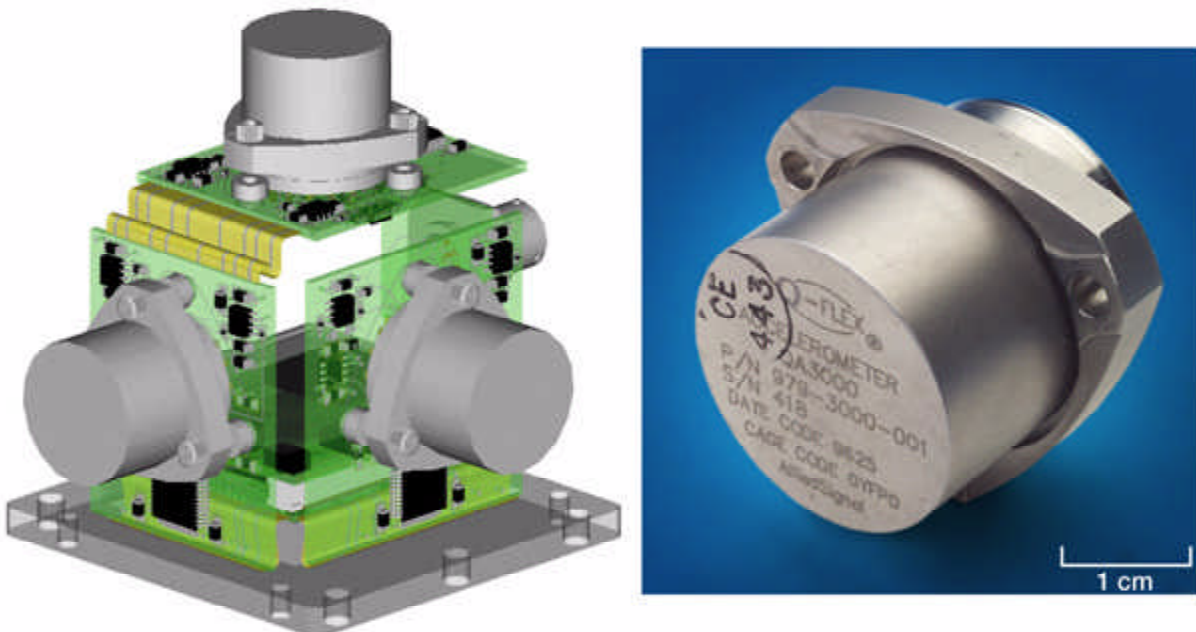


Advanced Microgravity Acceleration Measurement Systems (AMAMS) Being Developed

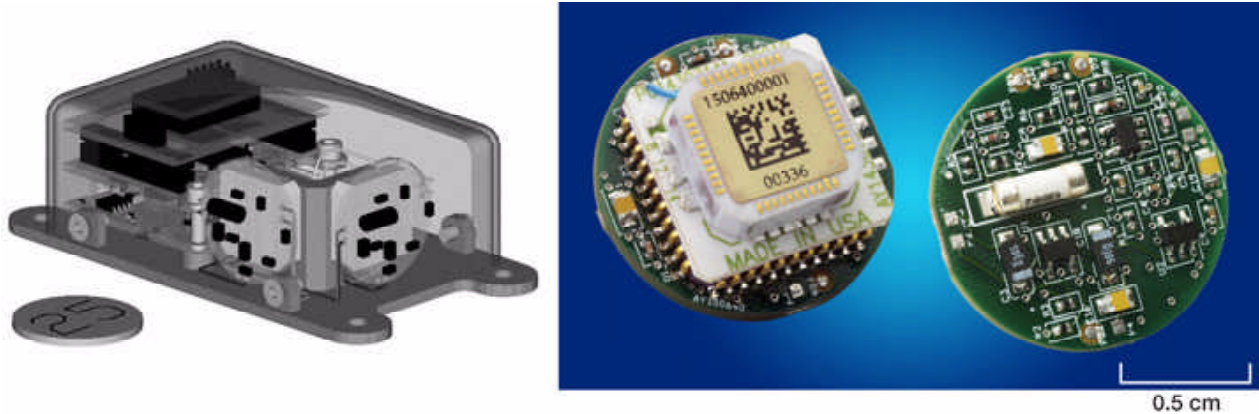
The Advanced Microgravity Acceleration Measurement Systems (AMAMS) project is part of NASA's Instrument Technology Development program to develop advanced sensor systems. The primary focus of the AMAMS project is to develop microelectromechanical systems (MEMS) for acceleration sensor systems to replace existing electromechanical sensor systems presently used to assess relative gravity levels aboard spacecraft. These systems are used to characterize both vehicle and payload responses to low-gravity vibroacoustic environments. The collection of microgravity acceleration data is useful to the microgravity life sciences, microgravity physical sciences, and structural dynamics communities. The inherent advantages of semiconductor-based systems are reduced size, mass, and power consumption, with enhanced long-term calibration stability.



Left: SAMS TSH-ES showing mounting of the AlliedSignal QA-3000 and the electronic interface card. Right: One AlliedSignal QA-3000 accelerometer.

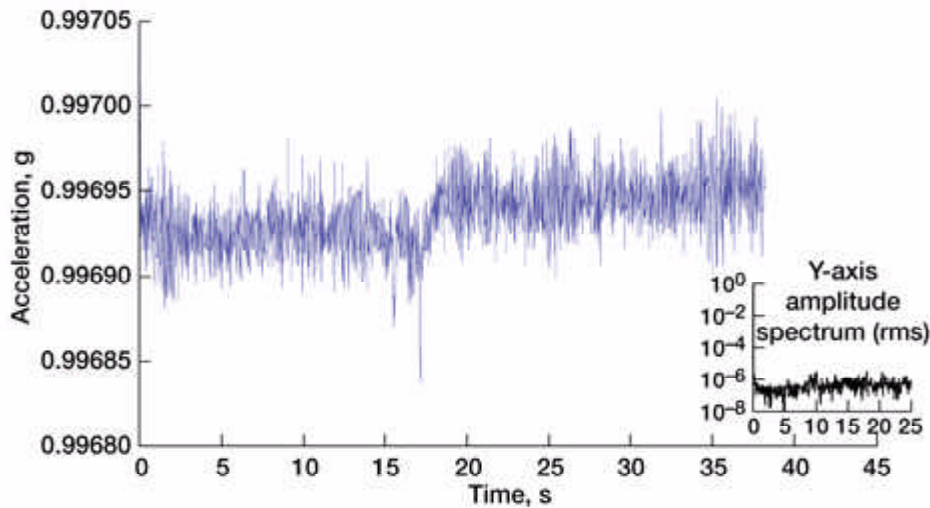
The AMAMS represents the fifth generation of triaxial sensor heads developed at the NASA Glenn Research Center for collecting microgravity acceleration data. Since 1991, the Space Acceleration Measurement System (SAMS) program has supported over 25 shuttle missions and the space station Mir, and has ongoing operations on the International Space Station (ISS). The first four generations-SAMS (original design, 1991 to 1998), SAMS-FF (1999 to 2003), SAMS-II (for the ISS, 2001 to the present), and SAMS TSH-ES (Ethernet, 2002 to present)-used AlliedSignal Q-flex accelerometers (see the preceding

photographs). AMAMS represents a new design approach using MEMS accelerometers (see the following illustration) and state-of-the-art analog-to-digital converters. In addition to saving a significant amount of on-orbit resources, we theorize that AMAMS would be more accurate than current sensors for long-duration (longer than 2 years) interplanetary missions since they use sensors without magnetics. The long-term accuracy and stability will be demonstrated with ground testing and operational experience.



Left: AMAMS design using Applied MEMS accelerometer and electronic interface card. Note that the small size allows the accelerometers to face inward. Right: Top and bottom of one MEMS accelerometer.

A market survey assessed three different MEMS accelerometers from Honeywell, AlliedSignal, and Applied MEMS that could produce microgravity ($10^{-6}g$, or $1\ \mu g$) resolution. A test program was conducted, and it was determined that the Applied MEMS sensor had the best combination of characteristics for a microgravity triaxial sensor head. These MEMS sensors were developed for the seismic and geological exploration communities, where the reduced size and weight offer inherent advantages over conventional mechanical devices. Testing was conducted with the Applied MEMS sensor at the Space Power Facility at Glenn's Plum Brook Facility to determine the noise floor. The results (see the graph) were very encouraging, yielding data that demonstrated that the Applied MEMS accelerometer combined with the prototype electronics can produce microgravity resolution in the general purpose 0.1- to 25-Hz range. The testing also verified the available 1500-Hz bandwidth of the Applied MEMS accelerometer.



Applied MEMS sensor in triaxial sensor head breadboard on bench at 50-Hz sample rate.

A design has been completed for the prototype triaxial sensor head and has met the goals of the Instrument Technology Development program proposal. High-resolution, 24-bit delta-sigma analog-to-digital conversion circuitry is employed to utilize the large dynamic range of the accelerometers. This sensor head design is controlled with a commercial processor board and has an RS-422 serial interface for external control and data storage. The resulting sensor head meets the goals of sensitivity less than 1 μg , with a resulting packaging size under 8 in.³, weight under 0.25 lb, power consumption less than 1 W, and component cost under \$2500. This represents a 33-percent reduction in volume, an 87-percent reduction in cost, and a 50-percent reduction in power consumption from previous designs. The prototype of this sensor is scheduled for completion in August 2003, and integrated testing is scheduled with the completed package.

In addition, a design study was conducted to investigate further miniaturization of the sensor package. This would be accomplished through the development of a custom hybrid package or application-specific integrated circuit (ASIC) for the signal conditioning and processor electronics circuitry. Several different designs were developed for progressively reducing the size as more sophisticated packaging techniques were employed. It is feasible to develop a triaxial sensor package that would be less than 5 in.³ and would utilize an Ethernet interface so that it could be implemented in the International Space Station Ethernet local area network. The smaller size requires less volume and allows the sensors to be located closer to the measurement location.

This work is part of a multiyear (2001 to 2003) effort funded by NASA's Office of Biological and Physical Research and based on a competitive proposal coauthored by Thomas J. Kacpura and Ronald J. Sicker. The work will be performed primarily at Zin Technologies with NASA management oversight.

Find out more about the research of Glenn's Microgravity Science Division
<http://microgravity.grc.nasa.gov/>.

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